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MICRO-CHRONOMETER FOR MEASURING DISTANCES
BY THE ECHO SOUNDING METHOD
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FIG. 1.

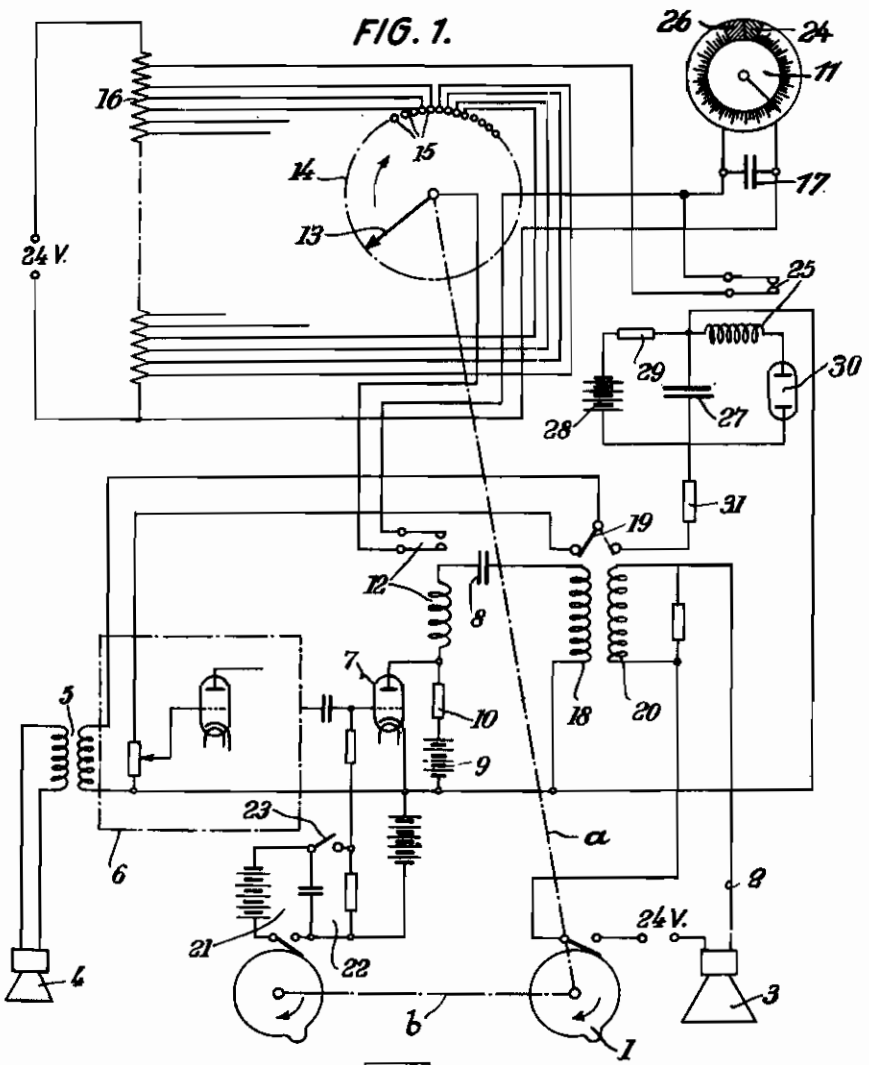
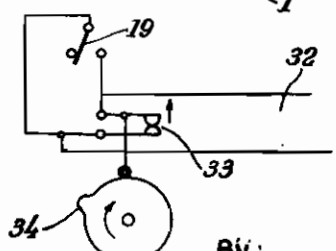


FIG. 2.



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ALIEN PROPERTY CUSTODIAN

MICRO-CHRONOMETER FOR MEASURING DISTANCES BY THE ECHO SOUNDING METHOD

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The invention relates to a micro-chronometer for measuring distances by the echo sounding method, by which sounds are emitted at certain intervals and the time required for the arrival of the echo from an object, whose distance is to be ascertained, serves as a measure for this distance, which is indicated on a distance scale by the echo impulse. In order to retain the indications of the echo impulses occurring at very short intervals, it has been proposed to construct the indicating device in such a way that an indication remains visible beyond the duration of the echo impulse and is removed only by means of a device actuated by a subsequent echo impulse. With this arrangement, it has been found that uncertainties are liable to occur owing to the fact that the indication, after the echo impulse has ceased, remains at the value corresponding to the last echo. Surely, the observer in an aeroplane, or for example the pilot when starting, will see from the unchanged indication that, for example, if flying beyond a certain altitude which is in the upper portion of the measuring range, no echoes arrive or that the echoes do not cause the device to respond. However, it may also occur that this cannot be discerned or not soon enough.

In order to preclude such uncertainties in reading the indication, the present invention provides an electric circuit which is interrupted or closed or influenced in any manner only in the case of echoes arriving in a certain order of succession, and which is arranged so that, if not influenced owing to non-arrival of echoes, after a certain time it removes the existing indication or produces an indication showing that the echoes do not arrive. In this way it is attained that the indication is removed or some other sign is given if during a certain period no echoes have arrived or have caused the device to respond.

Advantageously the removal or shifting of the indication is effected only after several echoes have failed to arrive, as in most cases it is not desired to have the indication removed if one single echo has failed to arrive. Thus, in the case of echo-sounding by an aeroplane it may occur frequently that some echoes do not arrive at the upper mark of the indicating range, which would not render useless the existing indication. It is, therefore, advisable to construct the device in such a way that the permanent indication is not interrupted if some echoes fail to arrive, but that the existing indication is removed only in case of non-arrival of a number of successive echoes. This is an advantage, particularly if the indication is effected by a pointer instrument, for example a voltmeter, as the pointer system, by rapidly switching off and on in each case of non-arrival of an echo, is subjected to such vibrations that it will take some time before it will come to rest again. These vibrations are especially large, as the non-arrival of echoes mostly occurs in the upper portion of the measuring range so that the pointer, each time the current is interrupted, has to move along the whole scale to reach the zero-position. Therefore, it is advantageous not to let the pointer return to the zero-position each time an echo fails to arrive, but to shift the existing indication to a place above the measuring range. In this way, the deflection of the indicating system is reduced to a minimum, bringing the system more rapidly to rest than when completely removing the existing indication. In addition, there is the advantage that the observer immediately knows, from the position of the indication, the working condition of the echo sounding device.

Advantageously, a condenser is provided, the loading condition of which is influenced by the arriving echoes, and which, in case the echoes fail to arrive, has a potential above or below a certain limit and thereby removes or shifts the existing indication. The potential of the condenser may in this case be used as grid potential for controlling a valve whose anode circuit effects the removal or shifting of the indication. The arrangement can also be made so that the condenser is discharged via a glow valve or a thyratron valve when the given limiting voltage is exceeded. This system has the advantage that the device is ready to indicate immediately after the removal or shifting has been effected, so that the first newly arriving echo is properly indicated.

The circuit effecting the removal may, according to another arrangement, be provided with two electric valves or switches, one of which is opened by the arriving echoes and is closed when the sound is emitted, whereas the other switch, serving as key, is momentarily closed or opened at certain intervals immediately before the sound is emitted. The two switches may be employed either in series connection, serving to effect the removal when both are closed, or in parallel connection, serving as current shunt and effecting the removal when both are opened.

In order that the removal should only be effected when several echoes have failed to arrive, the device may be arranged so that the key switch is actuated before each sound emission

and that the circuit serving for the removal in case of the non-arrival of echoes contains a time switch or time circuit or is arranged as time circuit in such a way that when the current is closed owing to non-arrival of an echo, the removal of the existing indication is effected only after several successive soundings, but that the time circuit or time switch is put in its initial condition on previous arrival of an echo.

The invention is illustrated by two constructional examples in the accompanying drawing in which:

Fig. 1 is the circuit diagram of an echo sounding device with a voltmeter as indicator, and

Fig. 2 is a part of the echo sounding device in a second form of construction.

The illustrated device serves for measuring the distance by the echo sounding method and will be described in its application to echo sounding by aeroplanes for measuring the altitude.

By means of a contact transmitter 1, revolving at a uniform speed and driven by a motor, not illustrated in the drawing, an emitting circuit 2 is momentarily connected, which actuates a sound emitter 3, for example a whistle for emitting a short sound impulse from the aeroplane directed towards the surface of the earth. The sound ray reflected by the surface of the earth is taken up by a receiver 4, which transforms it into electric energy and conducts it via an input transformer 5 to the first valve of an amplifier 6. The amplified echo impulse is conducted from the amplifier to the grid of a thyratron 7. The thyratron is in the discharge circuit of a condenser 8 which is charged by a source of potential 9 via a resistance 10. The discharge current impulse is used for controlling the actual indicating device.

For the purpose of ascertaining the time which lapses from the emission of the sound impulse up to the arrival of the echo, as a measure of the distance covered by the sound or of the altitude of the aeroplane, chronometers of known construction can be employed. In the form of construction shown in Fig. 1, the indication is effected by a voltmeter 11 which, at the moment of the arrival of the echo, is momentarily connected by a change-over relay 12 via a revolving time-giving member and a collector 14 to a more or less high potential according to the position of the time-giving member. The line *a*, which is to illustrate a wave, indicates that the time-giving member 13 is to revolve in synchronism with the contact transmitter, whereas the line *b* indicates a contact disc, similar to the time-giving member 1, with which it revolves in synchronism. The collector contacts 18 of the collector 14 are connected to a potentiometer 16, voltages increasing in certain amounts being coordinated to each contact 15, commencing at the zero-point of the collector. By unequal distribution of the potentiometer taps and of the collector contacts, the accuracy of reading as well as the accuracy of measuring in the various ranges of the scale can be divided so as to suit the respective purpose in the most favourable manner.

For obtaining a permanent indication, a condenser 17 is connected in parallel to the voltmeter, the condenser 17 being charged during the short period of connection and contact by the time-giving member 13, whereby the respective potential value is retained until the next echo is indicated.

In the circuit of the thyratron there is a second relay coil 19 for actuating the switch 19 which is connected to one pole of the secondary coil of the input transformer 5 and in one position joins this coil to the grid of the first amplifying valve, and in the other position disconnects the coil from the grid of the amplifying valve, so that no amplification of the echo indication can be effected. When the condenser 8 is discharged owing to ignition of the thyratron 7 by echo impulse, the switch 19 is brought by the relay coil 18 into the position shown in the drawing by a dashed line, in which position the input transformer 5 is short-circuited. The switching relay or the switch 19 is arranged in such a manner that it remains in its existing position in which the receiving device remains disconnected after arrival of the echo. In this way, it is attained that only the first echo is indicated. Therefore, multiple echoes, occurring in a particularly intense degree in aeroplane sounding, do not affect the indication. Only with the next sound emission the switch 18 is brought into the other position shown in the drawing by a continuous line by means of a second relay coil 20 or a mechanical switching device actuated by the emission impulse, so that the receiving device is ready to indicate the next echo.

With each sounding, the sensitivity of the device is readjusted to the existing altitude, the adjustment of the sensitivity being effected by regulating the negative grid bias of the thyratron by means of a charging and discharging circuit 21, 22, controlled in the rhythm of the soundings.

For testing the echo sounding device, a switch 23 is provided in the discharge circuit 22 by which the regulation of the negative grid bias can be disconnected, so that the thyratron continuously works with the highest sensitivity. Thereby it is attained that the receiving and indicating device responds to the direct sound. If this is not the case, it is a sign that there is a disturbance. The distance to be covered by the direct sound from the emitter to the receiver is smaller than the distance covered by the sound to the surface of the earth and back to the receiver, when the aeroplane rests on the earth in which case the altitude is zero. Therefore, the test indication is not within the scale of altitudes but is in the range marked 24 "Testing" below the zero-point of the scale of altitudes.

When the distance or altitude of a starting aeroplane exceeds a certain limit, the echoes cannot cause the device to respond. Then, the indication remains at the last value indicated and there is the danger of concluding that the altitude is unchanged. In the opposite case, an unchanged indication of altitude would cause uncertainty as to whether the altitude is actually constant or whether the indication has remained owing to non-arrival of echoes.

In order to preclude this uncertainty, a relay 25 is provided which in the case of non-arrival of several echoes momentarily conducts to the voltmeter 11 and the condenser 17 a potential above the range of potentials utilized for indicating. Accordingly, the scale of the indicator of altitudes is provided with an indicating range adjoining the top of the scale of altitudes marked 26 "Echo not arrived". The relay 25 is in the discharge circuit of a condenser 27 which is charged by a source of potential 28 via a resistance 28. The discharge is effected by a glow valve 30 which tilts when a certain limiting voltage is exceeded and thereby causes a sudden discharge current to

actuate the relay **25**. Parallel to the discharge circuit **25, 30**, there is a second discharge circuit which, on arrival of an echo, is closed by the polarized relay **19** provided for protection from re-echoes. The discharge resistance of this circuit consists of the resistance of the secondary coil of the input transformer **5** and an additional resistance **31**, and is so dimensioned that, in the case of regular arrival of echoes, the condenser **27** cannot be charged up to the limiting voltage required for tilting the valve **30** via the relay **25**. This limiting voltage is only reached if the discharge via the resistance **31** is not effected owing to non-arrival of echoes during several, for example three, successive sounding periods.

Fig. 2 shows a connection in which an indicating circuit **32** is interrupted, whereby the indication is removed as soon as only one echo has failed to arrive. The connection consists of a current shunt in one branch of which is located the echo protection switch **19**, and in the other branch a key **33** which is momentarily opened immediately before each sound emission by a cam **34** revolving in the rhythm of the soundings. If no echo has arrived up to then, the switch **19** lies on the left, and the circuit **32** is interrupted.

The invention is not confined to the example illustrated. There are various possible modifications and other forms of construction.

Thus, the discharge of the condenser **27** by the echo, instead of being effected via the re-echo protection switch, can be effected via some other relay actuated by the echo, for example by a valve controlled by the echo and normally locked by a corresponding grid bias. Instead of discharging the condenser **27** via a tilting valve **30** when the limiting voltage is reached, its potential may be used for locking or unlocking a valve in the circuit of the relay **25** when the limiting value is reached. Instead of closing a discharge circuit by the echo, it is possible to connect by the echo a source of potential to the condenser **27**, or the echo may serve to produce a direct voltage via a transformer and a rectifier, which direct voltage influences the condenser **27** in one way or another. Finally, the invention may be utilized in connection with other echo sounding devices, for example such in which the potential measuring the distance is supplied by the discharge of a condenser instead of by a rotating potentiometer, or in connection with plants having a multitude of indicating members.

It is essential that the device producing the indication of the echo impulse acts suddenly so that the indication is particularly distinct and does not appear like a gradual change of altitude.

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